Laser-Sharp Eyes Watching Earth's Polar Regions Change

ICESat laser validated to five-inch accuracy

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A spaceborne laser instrument has taken a significant leap forward on its way to helping scientists answer a handful of important questions about Earth's surface.

In results scientists are calling "spectacular," a team led by Jean-Bernard Minster of Scripps Institution of Oceanography at the University of California, San Diego, has verified the ultra-high precision of the instrument, the Geoscience Laser Altimeter System, or GLAS, aboard the NASA satellite ICESat (Ice, Cloud and land Elevation Satellite). **Researchers at the Salar de Uyuni**

Launched a year ago, ICESat and the GLAS data it is transmitting to researchers are helping determine how levels of Earth's polar ice sheets and glaciers are changing. The ICESat mission is designed to provide valuable information on important issues such as climate change and its impact on the polar regions.

On Feb. 11, Scripps researcher Helen Amanda Fricker and graduate student Adrian Borsa at the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics at Scripps calibrated the accuracy of GLAS's ability to measure the height of Earth's surface to within five inches, a remarkable agreement with precise surface readings (the so-called "ground truth"). The accuracy is especially impressive, the scientists say, given that the satellite travels nearly 400 miles above the surface at more than 16,000 miles per hour.

During each orbital pass of ICESat, the GLAS instrument fires laser pulses (not harmful to eyes) towards Earth at a rate of 40 pulses per second using a technology called lidar, (light detection and ranging). Since ICESat's launch in January 2003, several hundred million laser shots have been fired. By measuring the precise time it takes for the laser pulses to bounce back to the satellite, GLAS can detect its distance from Earth's surface.

Combining this with knowledge of the exact location of ICESat in its orbit (to about one inch), and the direction of the laser beam (to better than a thousandth of a degree), determined by the Center for Space Research (CSR) at the University of Texas at Austin, the height of the surface of Earth can be calculated. That information will be used to carefully calculate changes in Earth's surface elevation over time.

But in order to achieve that level of precision, Minster's group and their colleagues on the ICESat team have been working to demonstrate that GLAS's readings are indeed as accurate as they were designed to be. The "ultimate" calibration standard for the team is a set of Global Positioning System (GPS) data collected in 2002 in the Bolivian Andes on a giant salt flat called the Salar de Uyuni, one of the largest flat surfaces on Earth. Here Fricker, Borsa and others carefully mapped extremely precise GPS readings of a region so flat that the total range of elevations over a 60-by-60-mile area is less than three feet.

"Establishing such calibration and validation areas for space-based instruments represents a lot of painstaking work," said Borsa. For comparison, surveying the Salar de Uyuni took weeks of preparation, days of field work and months of data processing. ICESat passes over the area in less than ten seconds.

The team's topographic map of the Salar de Uyuni is thought to have an average accuracy of an inch or better, and offers a standard that they hoped could be approached by the readings from space. In the late afternoon of Feb. 11, Fricker and Borsa's computer calculations led to an uncannily close match between the Salar de Uyuni surface GPS data and the space-borne GLAS data.

"These results are simply spectacular," said Minster, a Scripps Institution professor. "If they are repeatable by future measurements, they show that this technology can indeed capture the minute surface elevation changes we are looking for, particularly on the ice sheets in reference to global climate change."

The first GLAS readings over the Salar de Uyuni were obtained on Oct. 27, 2003, on a crystal clear day with no clouds. A second pass was made three weeks later on a cloudy day, and GLAS readings from that pass confirmed and reinforced the accuracy estimated for the first pass. Scientists are especially satisfied with results from the second pass since it highlights the instrument's ability to operate satisfactorily through moderate cloud cover.

"The ICESat height estimate repeatability is impressive," said instrument scientist James Abshire of NASA. "This is far better than ever achieved before from space and is an outstanding result for this early in the mission." Abshire supervised the design and construction of the instrument at the NASA Goddard Space Flight Center in the 1990s. CSR's Bob Schutz, the GLAS science team leader, concurred. "The Uyuni result is a significant contribution toward the characterization of the GLAS instrument," he said.

Minster believes the results help pave the way for research using ICESat data and for future missions that require scientists to consistently and precisely study the evolution of ice sheets and other features over decades.

"We have gained enormous confidence in our ability to achieve change detection," said Minster. "With the help of future missions over the next decade or two we will be able to unravel seasonal and annual variations of the surface from long-term trends associated with climate change."

The initial concept for GLAS was first proposed nearly 15 years ago. The new achievement is the result of a long-term collaboration of scientists and engineers from NASA, the University of Texas at Austin, the University of Wisconsin, MIT, Scripps Institution and Ball Aerospace Corp., from Boulder, Colo.

"I'm filled with awe that the collaborative work of so many people and organizations ultimately converged on this success," said Minster.

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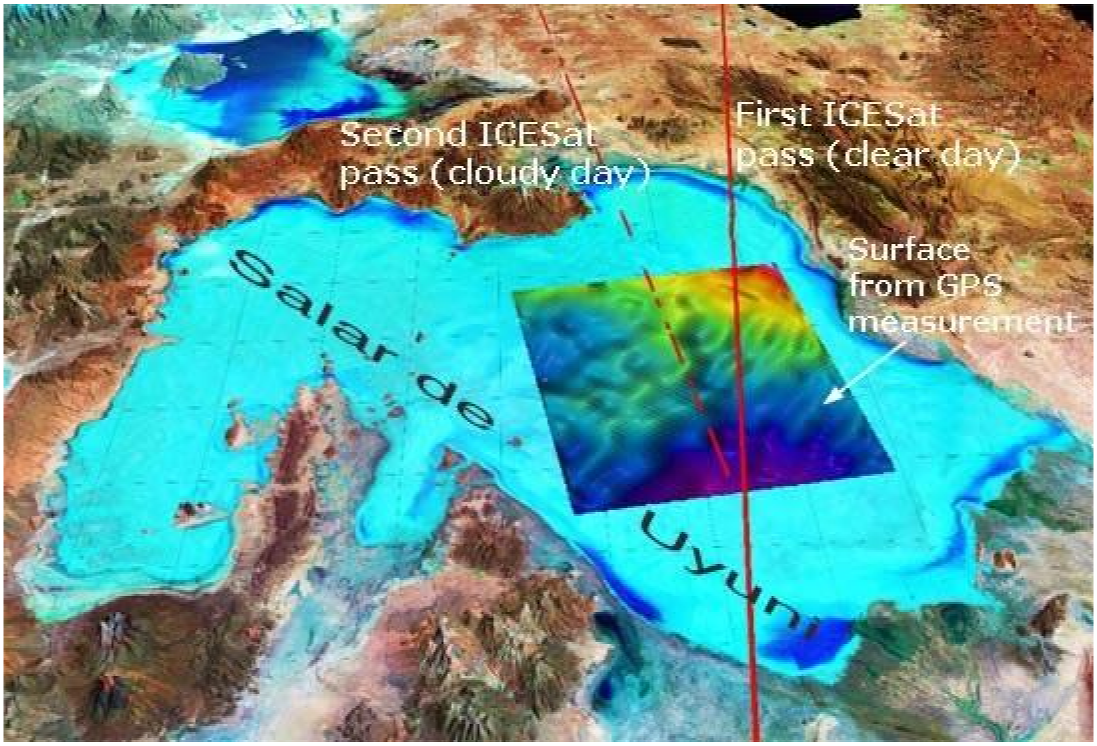
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